CLAIMS

What is claimed is:

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1. An asymmetric field ion mobility apparatus for identification of ion species, the apparatus comprising:

an ion filter disposed in a flow path, said flow path having a longitudinal axis for the flow of ions, said filter supplying an asymmetric filter field transverse to said longitudinal axis, said filter field being compensated;

an ion flow generator for longitudinally propelling ions along said flow path in said compensated asymmetric filter field; and

the ion filter passing a species of said propelled ions, said species having a set of characteristics correlated with said compensation, said correlation facilitating identification of said species.

2. Apparatus of claim 1 further comprising:

an ion source and a detection region, the ion flow generator providing a control of ions flowing in the filter from the ion source in a longitudinal direction toward the detection region.

3. Apparatus of claim 1 wherein the asymmetric field is compensated to prefer a species of ions to be passed through the filter by the flow generator.

4. Apparatus of claim 2 further comprising a detector in the detector region, the detector generating a detection signal representative of ion species passed by the filter.

5. Apparatus of claim 1 wherein said ion flow generator further comprises an electric propulsion field for providing said propelling.

6. Apparatus of claim 5 wherein said propulsion filed is a longitudinal electric field and wherein the control part includes an intelligent electronic controller, including a microprocessor, for controlling said compensated asymmetric field and said longitudinal field and for correlating said control with said detection signal.

7. Apparatus of claim 5 wherein the control part includes an intelligent electronic controller, including a microprocessor and lookup table, for controlling said compensated asymmetric field and said longitudinal propulsion with control signals and for correlating said control signals with said detection signal and said lookup table, for identifying said detected ion species.

8. Apparatus of claim 2 wherein the ion filter includes at least a pair of electrodes facing each other over the flow path having connection for an electric controller, said controller for applying a compensated asymmetric periodic voltage to filter electrodes.

9. Apparatus of claim 1 wherein the ion filter includes a plurality of electrodes facing each other over the flow path and having pads for connection to an electric controller, members of the plurality being used to create a filter field and a longitudinal propulsion field.

10. Apparatus of claim 9 wherein said members create said filter field and said propulsion field simultaneously.

11. Apparatus of claim 9 wherein said members create said filter field and said propulsion field simultaneously using different members of said plurality.

12. Apparatus of claim 2 wherein one or more sets of electrodes are used to create a filtering electric field for ion discrimination and the ion flow generator uses the same or a second set of electrodes to create an electric field at some angle to the filtering electric field for propelling said ions through the filtering field.

13. Apparatus of claim 12 further comprising an insulative or resistive layer over ones of the electrodes.

14. Apparatus of claim 1 further comprising a housing defining a planar, coaxial, concentric, or cylindrical geometry.

15. Apparatus of claim 2 wherein said ion flow generator provides a longitudinal electric field transport.

16. Apparatus of claim 15 wherein compensation is applied to said filter to pass ions forming a species sharing a common set of characteristics, said longitudinal field propelling ions through said asymmetric electric field according to said characteristics and said filter compensation.

17. Apparatus of claim 16 wherein the strength of said longitudinal electric field is either constant or varying in time or space, and may be pulsed.

18. Apparatus of claim 2 wherein said ion flow generator further comprises discrete electrodes supported by and insulated from said filter electrodes by an insulating medium.

19. Apparatus of claim 9 wherein said plurality of electrodes includes at least one ring electrode.

20. Apparatus of claim 9 wherein said plurality of electrodes includes at least one pair of planar electrodes.

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21. Apparatus of claim 1 further having an ion source and a detector region, a plurality of electrodes forming said ion flow generator and being used to create a propulsion field which flows ions in a longitudinal direction away from said ion source upstream of said flow path and toward said detector region downstream of said flow path.

22. Apparatus of claim 21 wherein said plurality of electrodes defines first and second sets of electrodes, said sets facing each other across said flow path, a longitudinal electric field being established between the electrodes of each set, each longitudinal field having a longitudinal flow direction downstream along said flow path toward said detector region.

23. Apparatus of claim 22 wherein said longitudinal fields are essentially equal.

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24. Apparatus of claim 23 wherein said first and second sets of electrodes each include a first bias electrode and a second bias electrode for application of a dc bias thereto, the first of said bias electrodes in each said set being biased relatively more negative than the second of said bias electrodes of each said set.

25. Apparatus of claim 24 wherein said first bias electrodes are negatively biased.

26. Apparatus of claim 24 further comprising an ion concentrating device, said device urging said ions toward the center of said flow path as they flow downstream in said filter.

27. Apparatus of claim 26 wherein said concentrating device includes said pairs of biased electrodes, wherein said propelled ions are driven toward the center of said flow path as they flow downstream down the center of said flow path.

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28. Apparatus of claim 12 wherein said filter electrodes are interspersed with said ion flow generator electrodes.

29. Apparatus of claim 28 further comprising a compensation source supply of a dc bias to ones of said electrodes to compensate said asymmetric field.

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30. Apparatus of claim 21 wherein said ion filter and said ion flow generator share common longitudinal space along said flow path.

31. Apparatus of claim 1 wherein said filter operates without a gas flow through it.

32. Apparatus of claim 1 wherein said filter operates with a reverse gas flow through it, said reverse gas flow traveling in a direction counter to that of said ion flow through said filter.

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33. Apparatus of claim 32 wherein said reverse gas flow includes a supply of clean filtered gas for cleansing of said ion filter and detector region.

34. Apparatus of claim 1 wherein said filter operates with a reduced gas flow through it.

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35 Apparatus of claim 1 wherein said ion flow generator includes spaced discrete electrodes along the flow path.

36. Apparatus of claim 35 wherein said ion filter includes at least a pair of electrodes facing each other over said flow path.

37. Apparatus of claim 36 wherein said ion filter electrodes are covered with an insulation layer.

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38. Apparatus of claim 37 wherein said ion flow generator electrodes are formed over said insulation layer.

39. Apparatus of claim 38 wherein ones of said electrodes are ring electrodes.

40. Apparatus of claim 9 wherein ions in said ions flow from an ionization region and are propelled by a low volume flow along the direction of said flow path longitudinal axis by an electric field.

41. Apparatus of claim 40 further comprising a resistive divider circuit to provide a potential gradient to ones of said electrodes for generation of said propulsion field.

42. Apparatus of claim 1 further comprising plurality of metal filter electrodes on insulating substrates, said substrates facing each other and forming said flow path.

43. Apparatus of claim 42 wherein said ion flow generator generates a longitudinal electric field for propulsion of said ions in said filter.

44. Apparatus of claim 43 wherein said electrodes are coated with a thin insulator and a resistive layer and propulsion electrodes are formed on said resistive layer for generation of said longitudinal electric field therebetween.

45. Apparatus of claim 44 wherein said propulsion electrodes make contact with said resistive layer to enable a voltage drop across that generates said longitudinal electric field

46. Apparatus of claim 9 said flow path defines a gap between said filter electrodes, further including a second flow path, said first and second flow paths joined by a passageway, further having a source for a sample-carrying gas, said second flow path for receipt of said sample-carrying gas, ions of said sample-carrying gas being flowed into said second flow path via said passageway.

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47. Apparatus of claim 46 further comprising deflection electrodes for deflection of said ions into said first flow path, said ions flowed into said gap by said ion flow generator.

48. Apparatus of claim 47 wherein said ion flow generator propels said ions through said asymmetric ion field.

49. Apparatus of claim 48 further comprising a pump to supply a low flow rate of air into said gap.

50. Apparatus of claim 49 further comprising a housing, said housing defining said flow path.

51. Apparatus of claim 50 wherein said housing includes a desiccant part for conditioning the sample before ion filtering.

52. Apparatus of claim 1 further including a plurality of high frequency, high voltage filter electrodes connected to an electric controller for application of an asymmetric periodic voltage to create said filter field.

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53. Apparatus of claim 52 wherein ones of said electrodes receive DC compensation from said controller.

54. Apparatus of claim 52 further including a plurality of electrodes for generation of an ion propelling electric field by said ion flow generator.

55. Apparatus of claim 54 wherein said high frequency electrodes and are driven while the longitudinal field producing electrodes have a potential developed across them.

56. Apparatus of claim 54 wherein said controller is configured where the voltages applied to the plurality of electrodes can be alternated between a

voltage applied to generate said filter field and a voltage applied to generate said propulsion field.

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57. Apparatus of claim 1 further including a plurality of filter electrodes connectable to an electric controller for application of an asymmetric periodic voltage to create said filter field, further including a plurality of electrodes for generation of an ion propelling electric field by said ion flow generator, wherein said high frequency electrodes are drivable while or interspersed with driving the longitudinal field producing electrodes.

58. Apparatus of claim 52 wherein said flow path is defined by insulating substrates and said high frequency electrodes are disposed on the outside walls of said insulating substrates.

59. Apparatus of claim 54 wherein said flow path is defined by insulating substrates and wherein a resistive material is deposited on the inside walls of said insulating substrates, and electrodes are formed associated therewith.

60. Apparatus of claim 52 wherein said filter field is generated by application of an asymmetric periodic voltage to ones of said electrodes, said filter field being compensated by varying the duty cycle of said asymmetric periodic voltage.

61. Apparatus of claim 54 wherein an electrical field presence is generated by driving several of said electrodes, said field presence having both transverse and longitudinal components to both filter and propel the ions, by application of a traveling wave voltage.

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62. Apparatus of claim 54 wherein an electrical field presence is generated by driving several of said electrodes, said field presence having both transverse and longitudinal components to both filter and propel the ions, wherein an RF signal is applied to the electrodes to generate a transverse RF filter field, which

is compensated, and said ion flow generator includes a selection of said electrodes biased to different voltage levels to generate a gradient along the flow path.

63. Apparatus of claim 62 including a controller for scanning said electrodes.

64. Apparatus of claim 1 further comprising a gas flow pump for flow of gas away from said filter in a counter gas flow.

65. Apparatus of claim 1 further comprising a molecular sieve located proximate to said filter to absorb neutral molecules.

66. Apparatus of claim 1 further including an ion detector proximate to the ion filter.

67 Apparatus of claim 1 further including an ionization source for ionization of a sample to generate ions to be flowed by said ion flow generator.

68. Apparatus of claim 67 wherein the ionization source includes a radiation source, an ultraviolet lamp, a corona discharge device, a plasma source or an electrospray nozzle.

69. An asymmetric field ion mobility spectrometer comprising:

a flow path for the flow of ions in a longitudinal direction from an ionization region toward a detector region;

an ion filter disposed in the flow path after the ionization region, the ion filter disposed in the flow path and supplying an asymmetric field transverse to the flow path;

an ion flow generator for creating a longitudinal transport field for propelling ions in the filter longitudinally along the flow path;

the asymmetric field transverse to the ion flow in the flow path; and

the ion filter passing ions toward the detector region as influenced by the transverse asymmetric field and as propelled by the longitudinal transport field.

70. Apparatus of claim 69 in which the ion filter is connected to an electric controller for applying an asymmetric periodic voltage to the ion filter, and wherein said ion filter includes a pair of spaced electrodes for creating a compensated asymmetric electric field and the ion flow generator includes a plurality of spaced electrodes for creating the longitudinal field.

71. Apparatus of claim 70 in which the ion filter includes a first plurality of discrete electrodes electrically connected to an electric controller which applies an asymmetric periodic voltage to the first plurality of discrete electrodes and in which the ion flow generator includes a second plurality of discrete electrodes dispersed among the first plurality of discrete electrodes connected to a voltage source which generates a potential gradient along the second plurality of discrete electrodes creating a preferential ion flow direction in said flow path.

72. Apparatus of claim 71 in which the gap between the filter electrodes is enclosed by a housing, said ion filter includes electrodes on a surface of the housing and the ion flow generator includes electrodes proximate to the ion filter.

73. Apparatus of claim 72 in which the ion detector includes electrodes on an inside surface of the housing proximate the ion filter and the ion flow generator.

74. Apparatus of claim 72 in which the gap is enclosed by a housing, the ion filter includes electrodes on an outside surface of the housing and the ion flow generator includes resistive layers on an inside surface of the housing and a voltage is applied along each layer to create a longitudinal electric field.

75. Apparatus of claim 69 wherein the ion filter and the ion flow generator are combined and include a series of discrete conductive elements each excited by a voltage source at a different phase.

76. Apparatus of claim 69 wherein the ion filter and the ion flow generator include a series of electrodes in said flow path each excited by a voltage source, electrodes associated with said flow generator having a multiphase signal applied thereto for generation of said longitudinal transport field.

77. Apparatus of claim 76 wherein said housing defines a pair of spaced substrates, said substrates disposing said ion filter within said flow path, the filter including a pair of spaced electrodes, one electrode associated with each substrate.

78. Apparatus of claim 77 further comprising a controller for selectively applying a bias voltage and an asymmetric periodic voltage across the filter electrodes to control the path of ions through the filter under influence of said ion flow generator, and an output region for delivery of ions passed by said filter for detection.

79. Apparatus of claim 78 further comprising a detector in said output region, said detector including a top electrode at a bias voltage and a bottom electrode at a selected bias voltage, said detector electrodes formed on said substrates.

80. Apparatus of claim 69 further comprising a housing for defining and enclosing said flow path between a sample inlet and an outlet.

81. Apparatus of claim 80 wherein said housing defines substrates for the formation of electrodes facing each other over said flow path.

82. Method for analysis of chemicals in a sample, comprising the steps of:

placing an ion filter in a flow path, said flow path having a longitudinal axis for the flow of ions,

driving said filter to create an asymmetric filter field transverse in said flow path to said longitudinal axis,

forming an ion flow generator in said flow path in cooperation with said ion filter,

driving said flow generator for longitudinally propelling ions along said flow path in said asymmetric filter field; and

compensating said filter field for passing a selected species of said propelled ions, said species having a set of characteristics correlated with said compensation, said correlation facilitating identification of said species.

83. Method of claim 82 further comprising the steps of:

providing a detector for detection of said ions passed by said filter.

84. Method of claim 83 further comprising the steps of:

providing an intelligent electronic controller, including a microprocessor, for controlling said compensated asymmetric field and said longitudinal field and for correlating said control with said detection signal.

85. Method of claim 83 further comprising the steps of:

providing an intelligent electronic controller, including a microprocessor and lookup table, for controlling said compensated asymmetric field and said longitudinal field with control signals and for correlating said control signals with said detection signal and said lookup table, for identifying said detected ion species.

86. Method of claim 83 wherein the ion filter includes at least a pair of electrodes facing each other over the flow path having connection for an electric controller, said controller for applying a compensated asymmetric periodic voltage to filter electrodes.

87. Method of claim 86 wherein the ion filter includes a plurality of electrodes facing each other over the flow path and having pads for connection to an electric controller, members of the plurality being used to create a filter field and a propulsion field.

88. Method of claim 87 wherein said members create said filter field and said propulsion field simultaneously.

89. Method of claim 87 wherein said members create said filter field and said propulsion field simultaneously using different members of said plurality.

90. Method of claim 87 wherein one or more sets of electrodes are used to create a filtering electric field for ion discrimination and the ion flow generator uses the same or a second set of electrodes to create an electric field at some angle to the filtering electric field for propelling said ions through the filtering field.

91. Method of claim 82 further providing a housing defining a planar, coaxial, concentric, radial or cylindrical geometry.

92. Method of claim 82 further comprising the step of application of compensation to said filter to pass ions forming said species sharing a common set of characteristics, said longitudinal field propelling ions through said asymmetric electric field according to said characteristics and said filter compensation.

93. Method of claim 82 further comprising the step of providing a longitudinal electric field that is either constant or varying in time or space.

94. Method of claim 82 further comprising the step of providing at least one ring electrode.

95. Method of claim 82 further comprising the step of providing at least a pair of planar electrodes facing each other over the flow path.

96. Method of claim 95 further comprising the step of micromachining said flow path and electrodes.

97. Method of claim 82 further having an ion source and a detector region, a plurality of electrodes forming said ion flow generator and being used to create a propulsion field which flows ions in a longitudinal direction away from said ion source upstream of said flow path and toward said detector region downstream of said flow path.

98. Method of claim 82 wherein said plurality of electrodes defines first and second sets of electrodes, said sets facing each other across said flow path, a longitudinal electric field being established between the electrodes of each set, each longitudinal field having a longitudinal flow direction downstream along said flow path toward said detector region.

99. Method of claim 98 wherein said longitudinal fields are essentially equal.

100. Method of claim 99 wherein said first and second sets of electrodes each include a first bias electrode and a second bias electrode for application of a dc bias thereto, the first of said bias electrodes in each said set being biased relatively more negative than the second of said bias electrodes of each said set.

101. Method of claim 100 further comprising an ion concentrating device, said device urging said ions toward the center of said flow path as they flow downstream in said filter.

102. Method of claim 101 wherein said concentrating device includes said pairs of biased electrodes, wherein said propelled ions are driven toward the center of said flow path as they flow downstream down the center of said flow path.

103. Method of claim 82 wherein the ion filter is operated without a carrier gas flowing therethrough.

104. Method of claim 82 wherein said filter operates with a reverse gas flow through it.

105. Method of claim 82 further comprising a housing, said housing defining said flow path.

106. Method of claim 105 further comprising a plurality of filter and propulsion electrodes, wherein said housing is defined by cooperating substrates on which said electrodes are formed.

107. Method of claim 106 wherein said electrodes include a plurality of high frequency, high voltage filter electrodes connected to an electric controller for application of an asymmetric periodic voltage to create said filter field.

108. Method of claim 107 wherein ones of said electrodes receive DC compensation from said controller.

109. Method of claim 82 further including a plurality of electrodes for generation of an ion propelling electric field by said ion flow generator.

110. Method of claim 82 wherein an electrical field presence is generated by driving several of said electrodes, said field presence having both transverse and longitudinal components to both filter and propel the ions, by application of a traveling wave voltage.

111. Method of claim 82 wherein an electrical field presence is generated by driving several of said electrodes, said field presence having both transverse and longitudinal components to both filter and propel the ions, wherein an RF signal is applied to the electrodes to generate a transverse RF filter field, which is compensated, and said ion flow generator includes a selection of said electrodes biased to different voltage levels to generate a gradient along the flow path.

112. Method of claim 82 further comprising a molecular sieve located proximate to said filter to absorb neutral molecules.

113. An asymmetric field ion mobility apparatus for identification of ion species, the apparatus comprising:

an ion filter disposed in a flow path, said flow path having a longitudinal axis for the flow of ions, said filter supplying an asymmetric filter field transverse to said longitudinal axis;

an ion flow generator for longitudinally propelling ions along said flow path in said asymmetric filter field; and

the ion filter passing a species of said propelled ions, said species having a set of correlated characteristics, said correlation facilitating identification of said species.

114. Apparatus of claim 113 wherein said species are propelled in a trajectory in said filter, each said ion species having a set of characteristics correlated with said trajectory, said correlation facilitating identification of said species.

115. Apparatus of claim 113 wherein said filtering is achieved without compensation of said filter field.

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116. Apparatus of claim 115 wherein an RF filter electrode is associated with a first substrate and a plurality of multi-function electrodes is associated with a second substrate and facing the filter electrode over the flow path.

117. Apparatus of claim 116 wherein the plurality of electrodes forms a segmented detector electrode and ions are filtered and detected by trajectory, being controlled by the asymmetric field and landing on an appropriate one of the detector electrode segments.

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118. Apparatus of claim 117 wherein said detector electrodes are monitored, wherein a particular species can be identified based on its trajectory for a given detection and based on the fields generated and the ion transport whether gas or electric field.

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